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**The Ejection Seat Test Database: A Resource for
Enabling Aircrew Safety and Survivability**

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**Air Force Research Laboratory
Human Effectiveness Directorate
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***The Ejection Seat Test Database:
A Resource for Enabling Aircrew Safety and Survivability***
Kyle Keller and John Plaga
Air Force Research Laboratory

Abstract: During an aircraft emergency where the crew has done everything possible, but has failed to recover the aircraft, the only option remaining is to eject. Since 1996, there have been over 170 ejections from USAF aircraft, with over 150 in the ACES II ejection seat. Of the ACES II ejections, over 80% of them resulted in the crewmember receiving minor or no injuries. This success rate can be attributed to the arduous engineering task of balancing the need to remove the crewmember from the aircraft as quickly as possible, but also as safely as possible. This is very complicated task given the varied airframes in use, diverse crew anthropometry, and large range of airspeeds in which the seat is required to operate. The safety and effectiveness of the designs are verified by the US Air Force and Navy using rocket sled ejection testing which began in the early 1960's (Figure 1). Since then, over 1000 ejection tests have been conducted; however, valuable records of the studies were not consistently structured, collected, or archived until the 1980's. This lack of cohesion has prevented effective use of the data and acted as an obstacle for understanding historical performance as well as setting priorities for future achievement. The Biomechanics Branch of the Air Force Research Laboratory (AFRL) has developed an Ejection Seat Test Database to collect, organize, and make this data useful for comparing and improving ejection seats and life support equipment. The query-optioned Database contains records such as photos, videos, test reports, flight equipment, and other test parameters from hundreds of ejection tests. This database is currently available to government personnel through a web interface and will help provide historical performance data to compare with future ejection seat and life support equipment testing.

Introduction: Ejection seats have been a primary focus of improvement for the DoD and international defense agencies since they were developed during World War II. These seats have been modified systematically in order to better accommodate the increasingly diverse pilot population, the various airframes used across the services within the Department of Defense, and to utilize new technology implemented for safety and comfort. As multiple alterations were being rapidly designed, testing of new egress prototypes became vital to ensure pilot safety and survival. The United States Air Force (USAF) has conducted experimental testing and performance

based assessments on ejection seats and personal protective equipment for over 50 years. This participation has allowed for the collection of fundamental data to establish human injury criteria used in many dynamic applications today.



Figure 1 - Ejection Seat Testing Performed by the USAF

As a result of the vast amount of data that has been and will continue to be accrued, it became necessary to create a database that will contain this information for historical purposes as well as future use. By organizing and storing the knowledge gained from experimentation in an easily accessible and user-friendly manner, the Air Force and other branches of the military, along with aircraft manufacturing companies and other research facilities, will be able to quickly and efficiently obtain information about previous investigations. This may provide insight on experimental design, minimize the need for testing and analysis that has already been completed, and guide the direction of future ejection seat and personal protective equipment research.

Background: The ejection seat made its first appearance in an aircraft during World War II. This technology was developed due to the loss of pilot lives

resulting from the low rates of survivability by 'bailing out' of an aircraft. Before ejection seats were utilized in airplanes, egress from an aircraft consisted of a pilot climbing out of the cockpit onto the wing or jumping from a nearby trap-door and parachuting to the ground. This method was suitable until airplanes were designed to fly at higher speeds. In addition, certain aircraft prototypes had propellers that hindered the egress process. It was therefore determined that a more fail-proof method was required to return pilots to safety if an ejection was inevitable. Germany made the first steps in visualizing and developing a technique for aircrew to egress out of an aircraft without having to jump out manually. Their concept was a seat that was powered by compressed air which, once deployed, would allow a pilot to egress from a crashing plane by launching them above the aircraft. This seat was developed by the German company, Heinkel, and, despite its crude and unconventional design, it saved dozens of pilot lives during the war (Figure 2). Due to the demonstrated success of the Heinkel seat, a British company under contract with the United States, Aircraft Mechanics Inc., examined the structure and design of a US Army Corps- captured Heinkel ejector seat. From this assessment the US determined the value and significance of the equipment and desired for it to be reengineered to better fit multiple airframes and further improve the safety of their pilots. Consequently, the ejection seat became a primary focus for many U.S. government organizations, and enhancements and modifications to the original design occurred rapidly. The projectile system of the ejection seat evolved from compressed air, to gun powder, and finally to the modern firing mechanism of an explosive rocket cartridge. Within a few years, other design modifications were implemented which included changes to the pull handle location, accommodations for anthropometrically varied pilot populations, and better restraints to protect the aircrew.

With every new design and revision made to the system, the need for seat and equipment testing became inevitable and essential. Investigations have been completed by manufacturers since the beginning stages of development; however the United States Air Force started its testing in the early 1960's. By the late 1970's, ejection seat experiments and flight equipment evaluations were becoming a vital part of the Air Force's research. This research helped to improve protective gear and accommodate the increasingly varied population of pilots and aircraft with the most suitable seat. Due to the vast amount of data collected during this time, and the substantial value of this information for future use, the Biomechanics Branch of the Air Force Research Laboratory identified the need

for ejection testing data management by developing the Ejection Seat Test Database in the late 1990's.



Figure 2 - An Early Heinkel Seat Design

Methods: The Ejection Seat Test Database consists of a Microsoft Access back-end SQL relational database, and a user-friendly front-end, created using Visual Studio 2005, which is used to view the webpage and easily sort, query and search the data. There are two main pages involved with the database, the input site and the webpage.

The input site (Figure 3) serves as the mechanism with which information from different experiments can be placed in appropriate categories and then automatically uploaded into the webpage by a website administrator. The page is broken down into four main sections: General Study Information, Test Information, Flight Equipment, and Seat Properties. Data from each category can be appended by clicking on the appropriate options and filling in the blank fields.

A study is first created for each cycle of tests that are done in the same time period and with the same particular goal by clicking on 'General Study Information' and then 'Add New Study'. After choosing these options, the investigator will then be prompted to enter the year in which the investigations were started. The programmed code will automatically assign a study number by analyzing if there were already experiments performed in that year or not. Once the number is determined, the tests will be entered under the newly

created study number by using the 'Add New Test' button. Typically the study number will be the year that the tests were started and the series number of that group of experiments. An example of this naming process would consist of the ejection tests completed by the Air Force Research Laboratory for the Night Vision System in 1997. The study number for this group would be E199702 because the experiments were started in 1997 and was the second series of tests entered into the database for that year. After the study number is assigned, other information such as where the tests were conducted, who performed the experiments, what time period the testing was completed in, and other pieces of data are collected in the 'General Study Information' page.



Figure 3 - Homepage of the Input Site

Each study is composed of individual tests that have valuable information obtained from the data reports such as: the weather conditions, the manikins used including any modifications, the aircraft forebody version, and the planned and actual ejection velocities for the individual tests. This information is then entered through the 'Test Information' column. Each test has a 'Flight Equipment' tab used for entering the flight equipment gear the manikin wore including helmets, coveralls, boots and other protective safety

gear. Next, seat properties are entered under the 'Seat Properties' tab which includes the seat moments of inertia, weight, and center of gravity. This data is significant as it allows analysis of the personal protective equipment and the ejection seat. To save time when entering data, an individual test or entire study can be selected and uploaded onto the page using a drop-down box for either case as shown in Figure 4. The drop-down boxes list the names in alpha-numeric order which makes searching quick and efficient for the users.

Figure 4 - Searching for data by Study or Test Designation

Basic test information is entered under the 'Flight Equipment' and 'Seat Properties' tabs, though additional data such as test reports, data files, and media files from the experiments are input directly to network folders using standard file naming conventions, folder structures, and file formats. Figure 5 shows how the data starting from a study is organized into its appropriate components in the database.

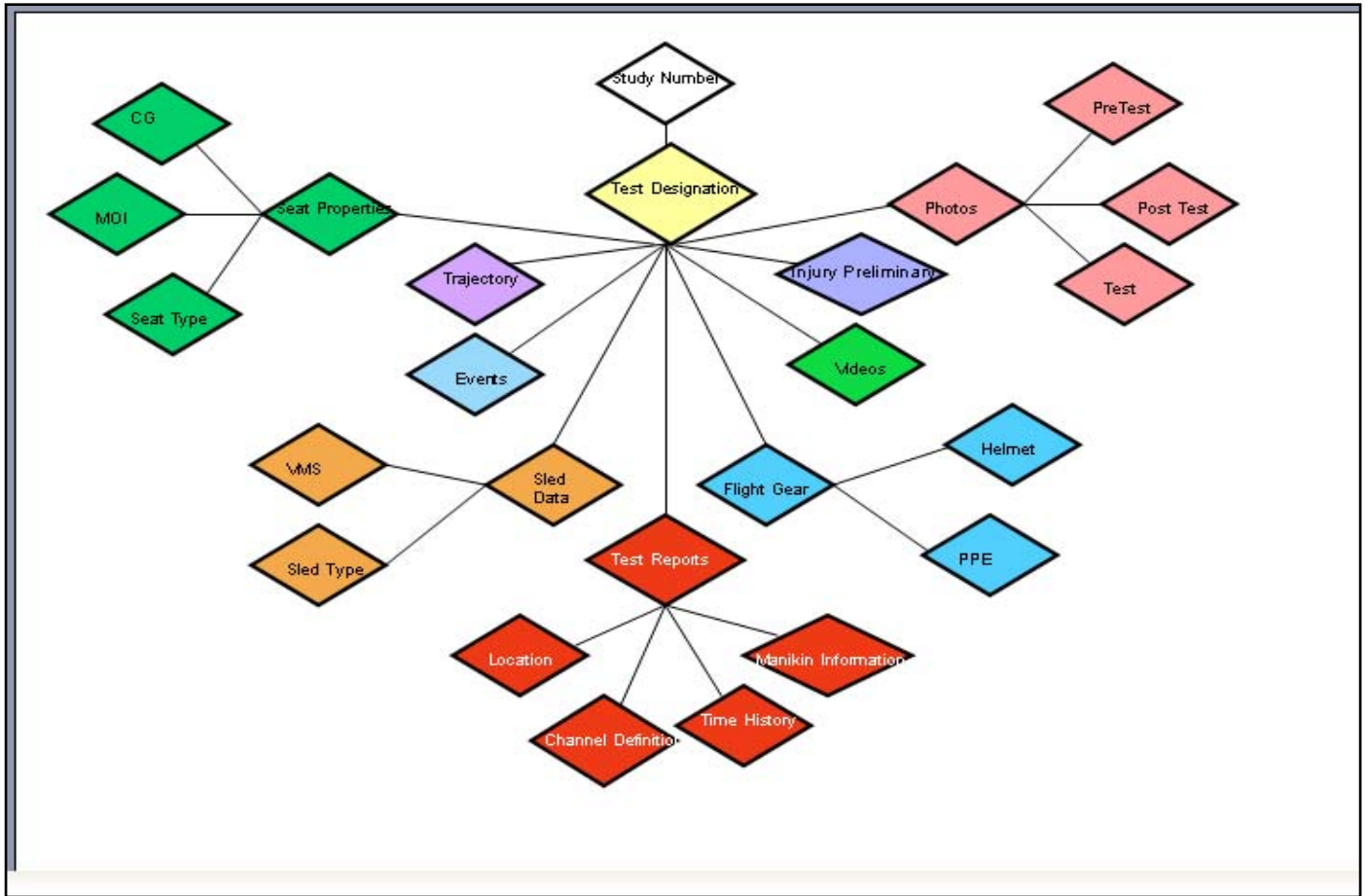


Figure 5 - Breakdown of Data

The goal of having an input page is to present a way to enter as much information from the tests as possible by providing an easy-to-use resource that will encourage users to fill in as many fields as possible. With the data being organized in searchable fields, it allows for users to search for specific data without having to look through an entire report or other file sources. An example is if a user wanted to inquire about which types of manikins were used for Study E199902 (C-9 Canopy Tests), they would pick a particular test from that study, and then find the Test Reports link. Information about the tests such as, the types of manikins used, serial numbers, weights, and other information about the test subjects is then accessible. Although there are other ways to find general information about the manikins such as by looking at the "Test Information" page, looking at the test report allows the users to obtain the most detail about the subject. The input user interface has a simple design which encourages the investigators entering the data to do it often and efficiently in order to provide an ideal means of data storage and structural organization.

The ejection webpage, currently accessible to government personnel only, is the user interface where the ejection test data is available for viewing and searching. The website is password protected in order to maintain control of confidential and proprietary data. Granular security controls will be added based upon a need-to-know basis in the future. Upon entering the webpage, users are able to choose from a variety of tabs in order to search for different records. Due to this database being a component of the Collaborative Biomechanics Data Network, by clicking on the 'Main Menu' tab users are given the opportunity to choose between 'Test Parameters', 'Anthropometry', or 'Bibliographic' data. If 'Test Parameters' is chosen it will lead the investigator into the 'Data Search' section of the ejection webpage (Figure 6).



Figure 6 - Homepage of the Ejection Seat Test Database Webpage

This 'Data Search' section allows a person to search for specific data by clicking on one or more options and obtaining the tests that meet the desired requirements. Different selections in which someone can search for information are: test facility, aircraft forebody, test dates, sled speed, study number and test designation, and others shown in Figure 7. One of the features included in the database design is the ability to select and sort by 'Study Number, Abbreviation, or Test Designation' on the data search page to narrow a search to specific studies. The search page is designed for front-end ease of use by having many options and simple click-and-go options which provides an efficient technique for finding specific data.

To narrow a search or inquire about specific details of experiments, multiple options can be clicked upon instead of choosing a certain test or study number. If there are certain parameters such as a particular test facility, manikin type, or a peculiar style of seat that was used, these search options can be selected to constrain the returned results. This prevents a user from spending a vast amount of time going through individual studies searching for this particular data. For example, if an investigator desires to know the details of each experiment that involved the use of an ACES II ejection seat with a Large Anthropomorphic Research Dummy (LARD), they would click on ACES II under 'seat type' and LARD under 'manikin type' on the data search page. After these choices are highlighted, the user then clicks 'Submit Query' as shown in Figure 8.

Figure 7 - Data Search Page for the Ejection Website

Figure 8 - Choosing the Desired Test Parameters

After choosing 'Submit Query' the next screen that uploads will display all of the experiments, from all the studies, that meet the conditions of having an ACES II ejection seat with a LARD manikin as the subject ID, as shown in Figure 9.

Rocket Sled Ejection Data									
Air Force Research Laboratory									
9 Selected Tests									
Subject ID: LARD Seat Type: ACES II									
Show All Results									
Test Designation	Position	Study No	Test Facility	Date	Forebody Type	Seat Type	Seat Vers on	Subj ID	Actual V (KEAS)
102E-A2	Forward	E200701	HMTT	2/15/2007	F-16	ACES II	N/A	LARD	451
90E-01	Forward	E199902	HAFB	2/24/2000	F-22	ACES II	F-16	LARD	473
92E-A2A	Forward	E200002	HAFB	1/31/2001	F-16	ACES II	F-16	LARD	177
92E-C2	Forward	E200002	HAFB	7/12/2001	F-16	ACES II	F-16	LARD	430
92E-G2	Forward	E200002	HAFB	8/29/2001	F-16	ACES II	F-16	LARD	515
92E-G2	Forward	E200002	HAFB	10/17/2001	F-16	ACES II	F-16	LARD	604
90E-A1	Forward	E200401	HMTT	6/25/2004	A-10	ACES II	N/A	LARD	0
97E-B1	Forward	E200302	HAFB	7/21/2005	F-16	ACES II	MODIFIED	LARD	589
HMTT-747	Forward	E200103	HMTT	5/23/2002	F-15	ACES II	F-15	LARD	602

Figure 9 - Results for Tests with ACES II Seat and LARD Manikin

Figure 9 illustrates how authorized personnel can discover basic test data quickly. Once the primary search has been completed, data about each experiment will be displayed on the results page such as: when and where the tests were conducted, the study number associated with each test, the seat version, and more. By having this data displayed, it allows users to swiftly obtain general information about the studies if they are only seeking a brief description. Each header for the general data that is shown can be clicked upon, which causes that particular column to be sorted from lowest to highest. For example, by clicking on the header labeled 'date' the results page will be sorted with the tests organized from the earliest tests performed to the most recent. This is another feature which allows for faster searches.

Users who are searching for detailed information about a specific series of tests have many options that can be utilized to acquire information on almost any aspect of data from individual experiments. After a 'search results' page loads based upon entering the desired conditions, additional data from these tests can be accessed by choosing one of the parameters listed on the side of the page such as test reports, sled data, channel definition, and other parameters that the tests are organized into. By clicking on one of these parameters, only data from that option will be displayed which allows users to see only the desired condition for an individual test. Near the top of the displayed results is located a pull-down box that can be used in a parallel manner as the side options. The difference lies in that by clicking on the choice that is

being requested such as test information, only the tests that have information about that particular selection are then listed. Once the relevant tests are shown, they can be clicked on individually to see the data for one particular experiment. This allows another way of finding available data instead of clicking every test. An example of both methods is when a user is looking for what flight gear was worn for a particular test. By choosing the 'Flight Equipment Data' from the drop down box or the side options and then choosing a specific test, the data will be displayed as shown in Figure 10.

Rocket Sled Ejection Data									
Air Force Research Laboratory									
Flight Equipment									
Back to Results									
Test Design: 92E-B1									
Position: Forward									
Test Info									
Seat Property									
Ejection Events									
Manikin Channel									
Sled Data									
Sled Data									
Photos									
Videos									
VMS Data									
Test Reports									
Test Designation	92E-B1	Position	Forward						
Helmet Type	HGU-56/P	Helmet Size	Medium						
Helmet Retained	Yes	ICNS	Yes						
CE	Yes	NVG/HMD	None						
Flash Blindness Goggles	None	Oxygen Mask Type	MBU-20/P Combat Edge						
Oxygen Mask Size	Small Narrow	Oxygen ITB/Connector Type	CRU-34/P						
Harness Type	PCU-16/P	Canopy Release	2nd Gen Koch						
Lumbar Pad	None	PADD	Yes						
Flight Jacket Type	None	Flight Jacket Size	n/a						
Life Preserver Type	LPU-9/P	Survival Vest Type	None						
Anti-G Garment Type	CSU-13B/P	Anti-G Garment Size	Small Regular						
Anti-G Vest Type	CSU-17/P	Anti-G Vest Size	Small						
Nonex Coverall Type	Commercial Orange	Nonex Coverall Size	34 Regular						
Personnel Lowering Device	None	Gloves Type	GS/FRP-2						
Gloves Size	7	Boots Type	FWU-8/P						
Boots Size	6	Anti-Exposure Garment Type	None						

Figure 10 - Flight Equipment Data for a Specific Test

Having data such as Flight Equipment, Seat Properties, General Test Information, and other parameters available at the start of a search emphasizes the database's user-friendly and efficient design.

Additional information included in the database are time history plots, photo data, and media files. This feature of the database serves to show the results of the tests in a more realistic sense, and to highlight the success or failure of the individual tests. The time history option on the webpage can be accessed using the same methods as before and is a collection of filtered sensor data gathered during an ejection event. It allows a user to click between multiple channels such as forces, accelerations, moments, and pressures in multiple axes and then plot the data either alone or against other channels. For example, if a user inquires about comparing the manikin's measured lumbar forces (X, Y, and Z axes) during Test 82E-B1, they

would choose these three options on the query page and then plot the data as shown in the Figures 11 and 12 below. The entire set of time series data can also be downloaded in MS Excel format. By having the ability to plot individual channels from multiple tests together, users are able to quickly obtain knowledge of abnormalities or errors in the data.

Select Channels to be plotted for Test: 82E-B1

<input type="checkbox"/> Chest Angular Acceleration About Y Axis (G)	<input type="checkbox"/> Chest Linear Acceleration, X Axis (G)
<input type="checkbox"/> Chest Linear Acceleration, Y Axis (G)	<input type="checkbox"/> Chest Linear Acceleration, Z Axis (G)
<input type="checkbox"/> Chest Total Pressure (PSI)	<input type="checkbox"/> Head Angular Acceleration, About Y Axis (G)
<input type="checkbox"/> Head Linear Acceleration, X Axis (G)	<input type="checkbox"/> Head Linear Acceleration, Y Axis (G)
<input type="checkbox"/> Head Linear Acceleration, Z Axis (G)	<input type="checkbox"/> Left Arm Lift (LB)
<input type="checkbox"/> Left Hip Abduction/Adduction (DEG)	<input type="checkbox"/> Left Hip Flexion/Extension (DEG)
<input type="checkbox"/> Left Knee Flexion (DEG)	<input type="checkbox"/> Left Leg Torque, Negative (LB)
<input type="checkbox"/> Left Leg Torque, Positive (LB)	<input type="checkbox"/> Left Parachute Riser Load (LB)
<input type="checkbox"/> Left Shoulder Flexion/Extension (DEG)	<input type="checkbox"/> Left Shoulder Medial/Lateral Rotation (DEG)
<input checked="" type="checkbox"/> Lower Base Pressure (PSI)	<input checked="" type="checkbox"/> Lumbar Force, X Axis (LB)
<input checked="" type="checkbox"/> Lumbar Force, Y Axis (LB)	<input checked="" type="checkbox"/> Lumbar Force, Z Axis (LB)
<input type="checkbox"/> Lumbar Linear Acceleration, X Axis (G)	<input type="checkbox"/> Lumbar Linear Acceleration, Y Axis (G)
<input type="checkbox"/> Lumbar Linear Acceleration, Z Axis (G)	<input type="checkbox"/> Lumbar Moment, X Axis (IN-LB)
<input type="checkbox"/> Lumbar Moment, Y Axis (IN-LB)	<input type="checkbox"/> Lumbar Moment, Z Axis (IN-LB)
<input type="checkbox"/> Neck Force, X Axis (LB)	<input type="checkbox"/> Neck Force, Y Axis (LB)
<input type="checkbox"/> Neck Force, Z Axis (LB)	<input type="checkbox"/> Neck Moment, About X Axis (IN-LB)
<input type="checkbox"/> Neck Moment, About Y Axis (IN-LB)	<input type="checkbox"/> Neck Moment, About Z Axis (IN-LB)
<input type="checkbox"/> Right Arm Lift (LB)	<input type="checkbox"/> Right Hip Abduction/Adduction (DEG)
<input type="checkbox"/> Right Hip Flexion/Extension (DEG)	<input type="checkbox"/> Right Knee Flexion (DEG)
<input type="checkbox"/> Right Leg Torque, Negative (LB)	<input type="checkbox"/> Right Leg Torque, Positive (LB)
<input type="checkbox"/> Right Parachute Riser Load (LB)	<input type="checkbox"/> Right Shoulder Flexion/Extension (DEG)
<input type="checkbox"/> Right Shoulder Medial/Lateral Rotation (DEG)	<input type="checkbox"/> Seat Angular Rate About X Axis (Roll Rate) (RAD/SEC)

Figure 11 - Choosing Options for Data Plotting

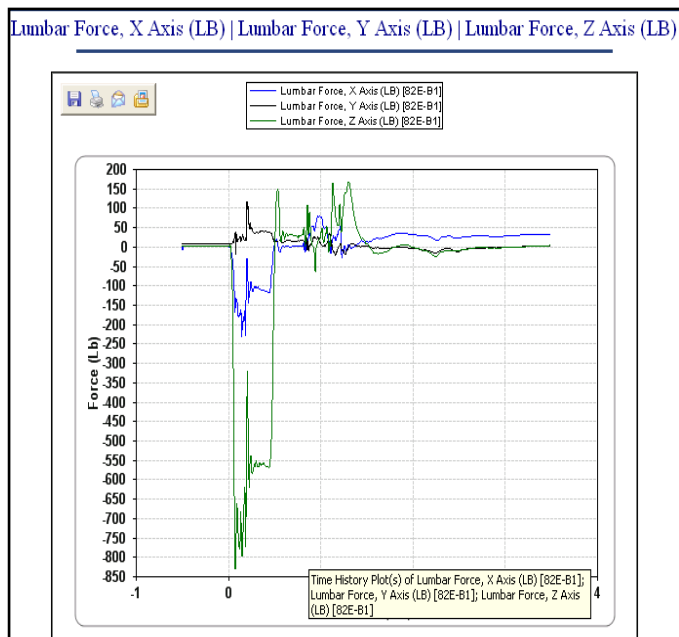


Figure 12 - Plot of Lumbar Forces in X, Y, and Z Axis vs. Time

As noted from Figure 12, there are negative time frames on the plot. This is due to the data collection system being initiated before the test commences in order to ensure that all of the parameters are captured from the moment the test begins. The time scale is later adjusted to start at seat system initiation, also known as time zero.

The photo data (Figure 13) and video files provide a visual documentation of the test. The photo data is organized by test designation, and each test is then divided into pretest, test, and post test. Having the photos divided in this manner allows users to narrow their search based on their interests. To access these photos, the drop box or side choices on the webpage contain a 'Photos' option. By clicking on an individual test of interest, a screen with each division of the photos will appear which states how many photos are in each option. As an example, if a user wished to know what the post test photos for test 92E-C3 consisted of, they would choose 'Photo Data' from the drop down box and then click on the test name. Once the next screen appears, the 'Post Test' photographs would be chosen and then the photos for that section would appear. By clicking on an individual photo, it will enlarge the picture for an enhanced view.

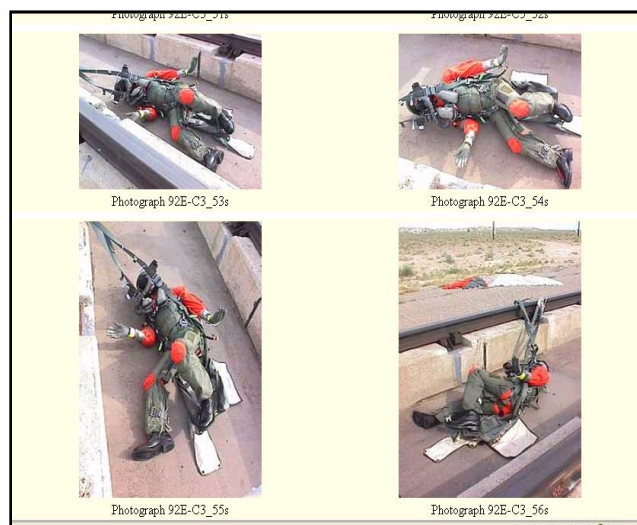


Figure 13 - Post Test Photos

The photo data also allows users to see the preparations taken before the test, the test itself, and the results of the experimentation. Access to these pictures enhances knowledge about what caused success or failure of an investigation and how the tests can be altered in the future. Video of the testing is also available for viewing. Various cameras are positioned along the track as well as in the cockpit to enhance the collection of data. The high-resolution cameras allow

users and investigators to see many details of the test including if the pilot egresses safely, if there is damage to the sled or seat, if all components of the experiment worked as planned, and other specific features. The video data is a primary source of information which allows analysis of how the seat and equipment performed, and if the test was a failure and why. Video data is sorted by test designation, and each camera serves as a different video for that test. The films are encoded as Windows Media Version 9.wmv files. On the webpage these files are found in the same user-friendly manner as the other files under the 'video data' tab.

Discussion: The Ejection Seat Test Database and its many components will be useful in the future providing government personnel are willing to utilize it and see the benefits it can present. Some may speculate that the database is not useful as it does not have every field filled in with data. Currently however, there are over 120 studies and 1100 tests queryable through the webpage that contain more than 17 GB of photo data, 5 GB of seat property data and, 3 GB of tests reports. The data spans over 30 years, and database is still being populated as additional information is obtained. Although all of the fields for the various categories are not complete, the Ejection Seat Test Database still serves as one of the fastest and most up-to-date resources for the Air Force to use for finding information on ejection seat and personal protective equipment research.

In order to provide evidence of the value the database presents, the question has been raised of whether government personnel would find the resource helpful in their work and if it is user-friendly. One example of the value of the database is a recent study of the Break-away Integrated Chin Nape Strap (BICNS). A researcher was given the task of obtaining data such as manikin type and modifications, injury data, helmet type and other test parameters for specific ejection seat tests. After acquiring the information by reading through dozens of test reports, the researcher had to create by hand data plots for injury criteria based on neck loads, tension, and flexion for each phase of the testing and then determine if each test passed or failed based upon applied neck injury criteria. This project took the researcher over three weeks to complete because of the tedious effort to search through hard-copies of reports and through various unorganized data files to find all pertinent data, and then manually analyze the data. During the time that he worked on this project the Ejection Seat Test Database was not populated and he was unable to use this resource. After showing him the database and navigating through the various tabs, the researcher

stated how he would have been able to complete the project in a far less amount of time due to being able to find the electronic report data quickly as well as having the ability to formulate the injury plots on the webpage. This example shows that the database is not only useful for finding records about ejection testing, but also the many other aspects of understanding and conducting ejection seat research. It can reduce the amount of time that would be used by inquirers for finding information by going through and manually read reports, avoids users from having to search through unorganized files, and also allows users to look for the specific data they are seeking in an organized manner.

The database can be utilized for various applications beyond ejection seat or personal protective equipment testing evaluation. With the amount of data that is stored and organized in the database, it has the versatility to aid in the validation of research involving NASA, NASCAR, Dynamic Injury Modeling, and a wide range of other experimentation.

NASA is involved in completing extensive data collection on the landing capsules that return astronauts to Earth (Figure 14). Their goal is to gather information from previous landings, as well as ejection testing in order to provide the best way for returning the aircrew to the ground with the least amount of injury to both the crew and the capsule.



Figure 14 - Landing Capsule Concept

This study, which is being completed in collaboration with the Air Force Research Lab, has had an extensive focus on seat designs, spinal loading, acceleration parameters, restraint systems, and flight gear in order to improve the results of each landing. By changing one of these elements, all of the other dimensions must be looked at to view the cause-and-effect of the modifications and to determine how the safety of the astronauts will be influenced during return to Earth. By using the Ejection Seat Test Database and comparing various parameters such as acceleration changes, neck and spinal forces, and seat orientation

during ejection seat testing to the models built for capsule testing, validation of the data can be performed. This can lead to a better understanding of the direction of future investigations and how to improve the design and safety of capsule landing.

Another example where the Ejection Seat Test Database can be used is in researching safety for race car drivers. Race car driving is a dangerous sport with an average of over six crashes per race, which can involve multiple cars, and over forty races per season in NASCAR. Due to these high crash rates and the speeds in which the competitions are performed, the dynamic environment of the crash is similar to that of a pilot ejection. Comparative analysis between the impact data from the Ejection Seat Test Database to the race car crash data is used to understand human acceleration limits. By evaluating the sets of data, neck loads and structural integrity are analyzed, and design modifications to the protective equipment and the cars are developed.

A final example of where the Ejection Seat Test Database can be used is in validating Dynamic Injury Models. Dynamic Injury Modeling is a technique used by scientists in which a representation of a human in a dynamic scenario is used for predictive injury evaluation and comparative research. For these models to be useful, they must be validated using experimental data. Some of the experimental data that can be used for human Biodynamics modeling include data from wind tunnels, ejection sled testing, and tests from the Vertical Deceleration Tower and Human Impact Decelerator test facilities in AFRL. The Ejection Seat Test Database serves as a key component for modeling because the stored data can be used for validation of the simulated results and also a baseline for future testing. By having access to the research done in the past, parameters such as configuration of tests, velocities, types of equipment to be used, and more can be predicted to provide more successful results. This resource also can be used to evaluate the data gathered from model simulation verses experimental testing, which can provide information about whether the replication is comparable to the authentic tests.

The three aforementioned examples display how the database can be useful to a variety of scientists. It allows other research projects to use the data for comparison, reduces redundant testing, and can provide information on ways to improve current testing of new safety and performance equipment.

Conclusion: The Ejection Seat Test Database houses over 30 years of technical reports, photographs, media files and other data files that contain the past, present, and future of ejection and personal protective equipment testing. With the database having the ability to store and organize data in a secure and user-friendly manner, it provides the Air Force, along with other research groups and engineers, the ability to quickly and efficiently discover the relevant information in minutes rather than hours, days or weeks. With its user-friendly features and basic design, it allows users to maintain the data more accurately and also permits changes to the input site or webpage format. This serves as another key component allowing the database to be changed as ejection testing is modified in the future. This resource will provide access to the past in order to help establish the future of ejection seat, personal protective equipment, and injury research.

References:

1. Tuttle, Jim. "Basic Ejection Seats." Eject! The Complete History of U.S. Aircraft Escape Systems. St. Paul: MBI, 2002. 23-31
2. Coyne, Kevin. "The Pioneers." The Ejection Site. 2002. Retrieved: 04/12/2008
<http://www.ejectionseat.com>
3. Cheng, H., Mosher, S. Buhrman, J.R. (2004) Development and Use of the Biodynamics Data Bank and Its Web Interface. Air Force Research Laboratory Biomechanics Branch.
4. St. John, A. "Anatomy of a NASCAR Crash." Popular Mechanics. 2008 Retrieved: 04/30/2008
<http://www.popularmechanics.com>